

Relating Mobile Phone Traffic Data to Base Station Exposure

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INTRODUCTION

The temporal variations of radio-frequency (RF) signals of base stations used in wireless systems such as GSM and UMTS are important for epidemiological studies and for authorities. Measurement periods to characterize temporal behavior of exposures may be very long, indicating the necessity of methodologies to estimate maximal and average exposure from short-period measurement data. Therefore, a method to calculate the fields at a time instant from fields at another time instant using normalized Erlang values (representing the average traffic intensity or occupancy during a period of time) is proposed. This enables the estimation of maximal and average exposure during a week from short-period measurements using only Erlang data and avoids the necessity of long measurement times.

MATERIALS AND METHODS

Temporal electric-field strength measurements of GSM (900 and 1800 MHz), UMTS, and FM signals are executed in a sequence of 1 to 3 minutes during 7 days. Measurements with a spectrum analyzer (SA) and electric-field strength probe are performed at 5 different sites depending on the type of environment, population density, and the amount of mobile phone traffic [1], [2]. The sites are noted as residential area (site 1), rural terrain (site 2), office environment (suburban, site 3), urban environment (site 4), and industrial environment (site 5). A momentary value of the electric-field strength (noted as E_{mom}) due to an RF signal is defined here as a sample of the total electric-field strength of a signal at a certain moment obtained each 1 to 3 minutes with the spectrum analyzer. **Erlang_{norm}** is defined as the vector of Erlang values and normalized Erlang values in the interval (0,1) during 7 days. The Erlang values are obtained from the wireless telecom operators in Belgium. In order to compare exposure measurements with traffic data (from the different sites on the measurement days), the normalized total electric field strength of GSM signals E_{norm} is compared with the normalized Erlang values **Erlang_{norm}** while E_{norm} is defined as follows:

$$E_{norm} = \frac{E_{mom} - \min(E_{mom})}{\max(E_{mom}) - \min(E_{mom})} \quad [-] \quad (1)$$

E_{mom} represents the array of momentary electric field strengths, min and max are the minimum and maximum values during the measurement period of 7 days. E_{norm} is normalized according to (1) which yields values between 0 and 1.

RESULTS

Fig. 1 shows a similar trend in normalized electric field strengths and normalized Erlang data (provided by the operator). Highest exposures occur during late morning, noon, afternoon, and evening. At night (12 am – 6 am) the values are very small. So we propose the following approach to calculate the maximal electric field strength E_{calc}^{max} and average electric field strength E_{calc}^{avg} during 24 hours from a momentary field value $E_{mom}(t)$ at time instant t at a location:

$$E_{calc}^{max} = E_{mom}(t) \cdot \frac{\max(\mathbf{Erlang})}{\mathbf{Erlang}(t)} = \frac{E_{mom}(t)}{\mathbf{Erlang}_{norm}(t)} ; E_{calc}^{avg} = E_{mom}(t) \cdot \frac{\langle \mathbf{Erlang} \rangle}{\mathbf{Erlang}(t)} \quad (2)$$

With $\langle \mathbf{Erlang} \rangle$ and $\max(\mathbf{Erlang})$ the average and maximal value of Erlang data during 24 hours at a location, respectively. $\mathbf{Erlang}(t)$ and $\mathbf{Erlang}_{norm}(t)$ are the Erlang value and the normalized Erlang value at time instant t , respectively.

To test the method; we now calculate for each site E_{calc}^{max} and E_{calc}^{avg} . We consider data measured between 8am and 6pm during weekdays as these are typical working hours during which control agencies can make their measurements. Moreover Erlang data during night are less usable due to the low traffic, resulting in small Erlang values. From the measurement data during 7 days we determine the true maximal field value $E_{true}^{max} = \max(\mathbf{E}_{mom})$ and the true average value $E_{true}^{avg} = \langle \mathbf{E}_{mom} \rangle$ of the GSM signals. For each site we then calculate the relative difference between the true and calculated values. The relative differences between estimated and true maximal and average values vary from 8.2 to 33.6 %. These deviations are acceptable because Erlang data are averaged over different neighboring base station sites and over data from different operators. Moreover a typical measurement uncertainty for the electric field strength is ± 3 dB for the considered setup, thus these differences are within this uncertainty. To execute this method Erlang data must be provided by each operator.

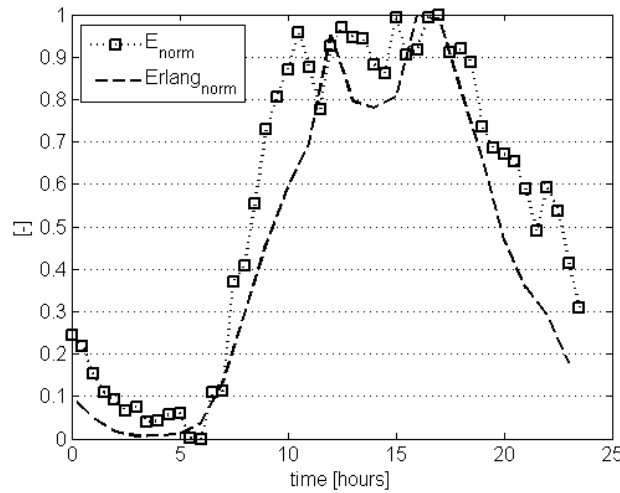


Figure 1: Comparison of E_{norm} and $Erlang_{norm}$ versus time during 24 hours for an urban environment (site 4).

CONCLUSIONS

A simple method to calculate electric-field values at a time instant from field values at another time instant using only Erlang data is presented. The deviations between true and calculated values of maximal and average exposure obtained using this approach, are limited if one uses Erlang data during day time. Control agencies can use this approach in practice to check whether maximal exposure values are compliant with limits. This method can only be used for GSM signals as Erlang is only a useful quantity for GSM voice traffic but if one has access to traffic data of UMTS, WiMAX, or LTE a similar approach could be applied.

REFERENCES

- [1] W. Joseph and L. Verloock, "Influence of traffic on general public base station exposure", *Health Physics*, vol 99, no 5, pp. 631-638, 2010.
- [2] W. Joseph, L. Verloock, E. Tanghe, and L. Martens, "In-situ measurement procedures for temporal RF electromagnetic field exposure of the general public", *Health Phys*, vol 96, no 5, pp. 529-542, May 2009.